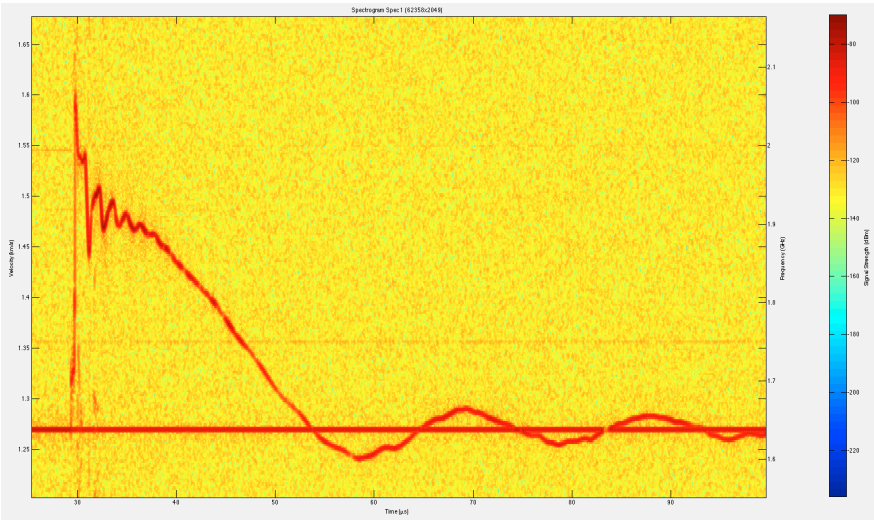
DOE/NV/25946--2127

Comparing Velocity Extraction Techniques and Benchmarking using High-Speed Video in an Impact Gas Gun Experiment



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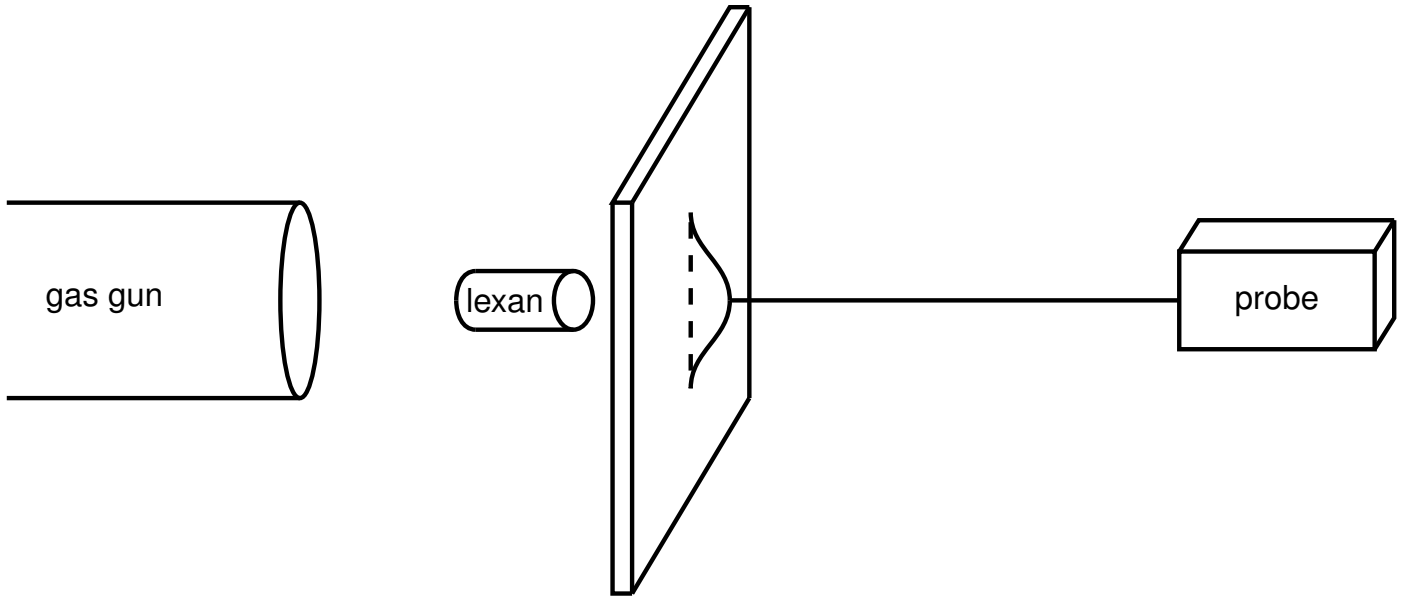
This work was done by National Security Technologies, LLC, under Contract No. DE-AC52-06NA25946 with the U.S. Department of Energy and supported by the Site-Directed Research and Development Program.

Gas Gun Setup



A lexan glass projectile was fired at an A036 steel plate and the surface deformation was studied using PDV.

PDV Velocity Extraction Techniques

Phase Estimate Methods

Statistics Based Spline Fit (SBSF)

- A cubic spline is fit to the phase estimate using global weighted-least-squares.

Local Polynomial Approximation (LPA)

- A polynomial is fit to the phase estimate in a small interval about each time.

Frequency-Based Fourier Methods

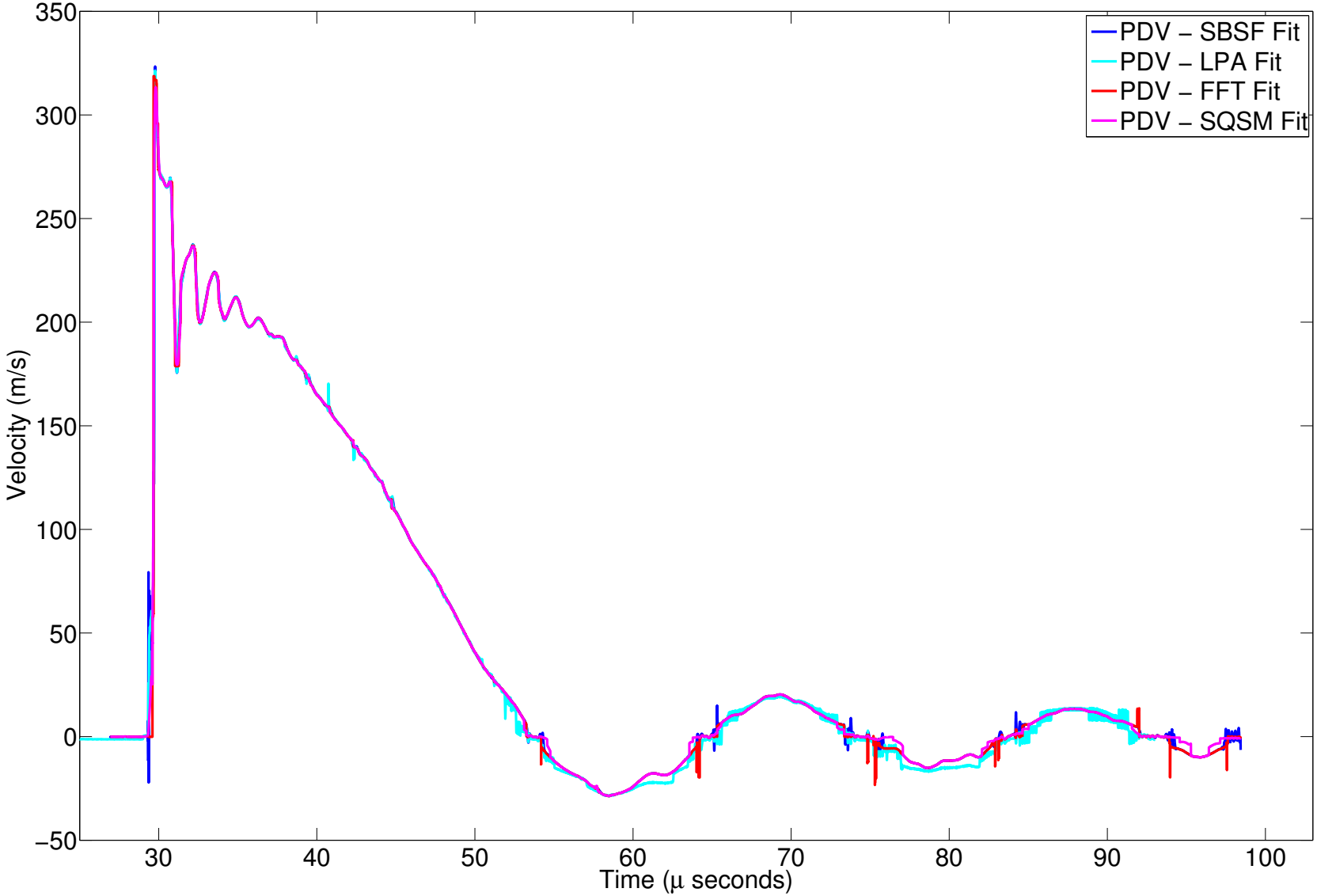
Interpolated FFT (FFT)

- Interpolation between points of dominant frequency, computed from the short-time Fourier transform of the signal.

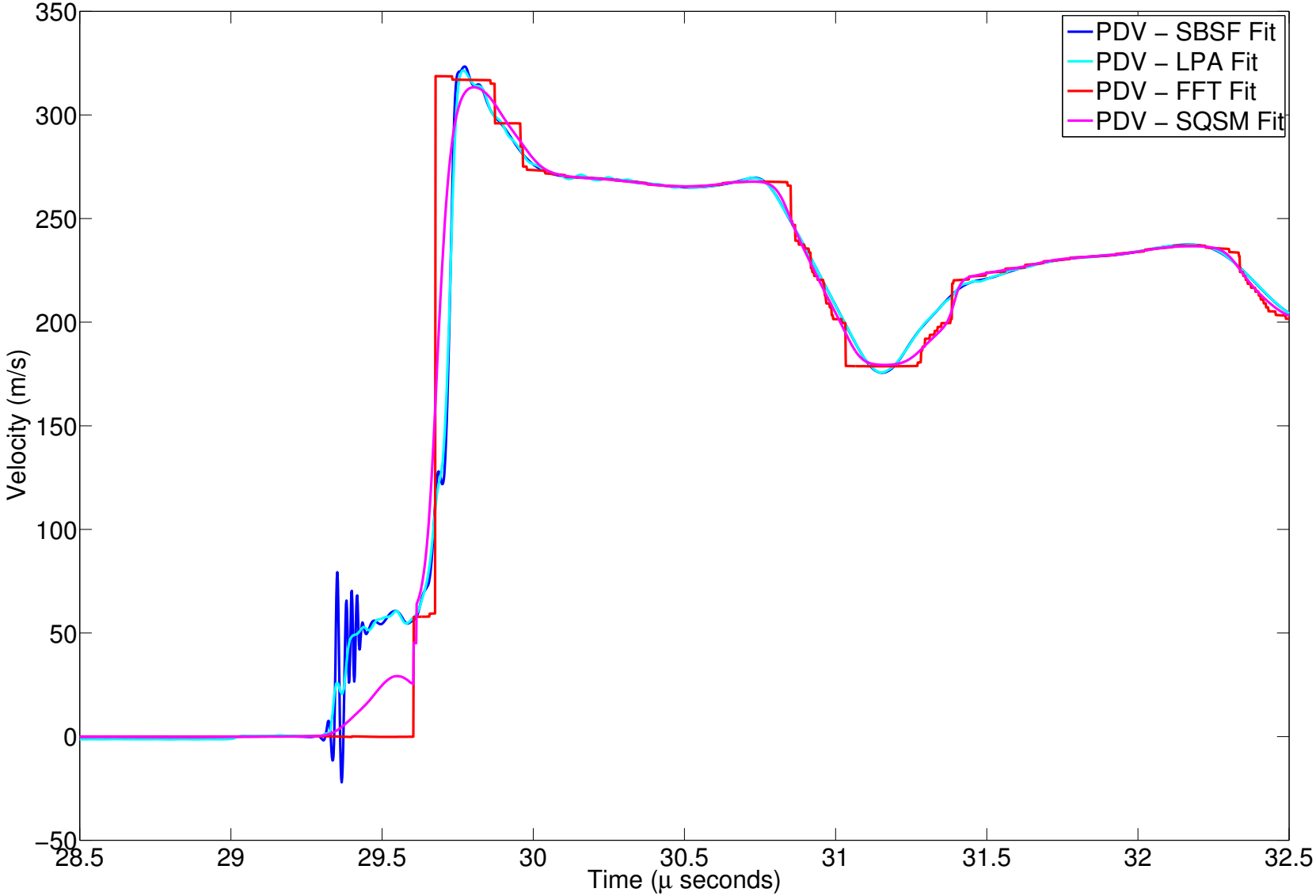
Squared Second Moment (SQSM)

- Computes measures of center and spread of the frequency at each time step in the transformed domain.

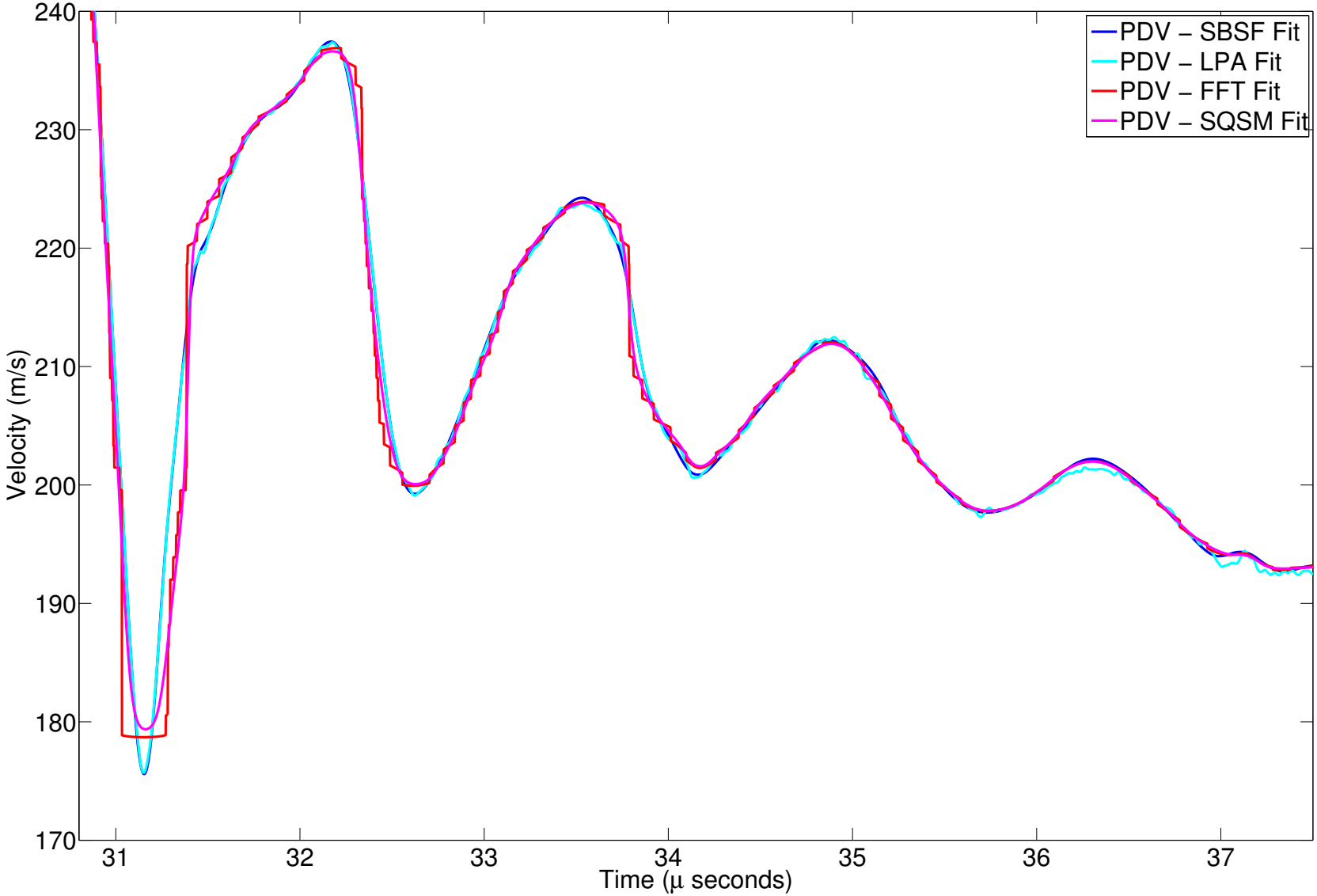
Velocity Extraction Comparison



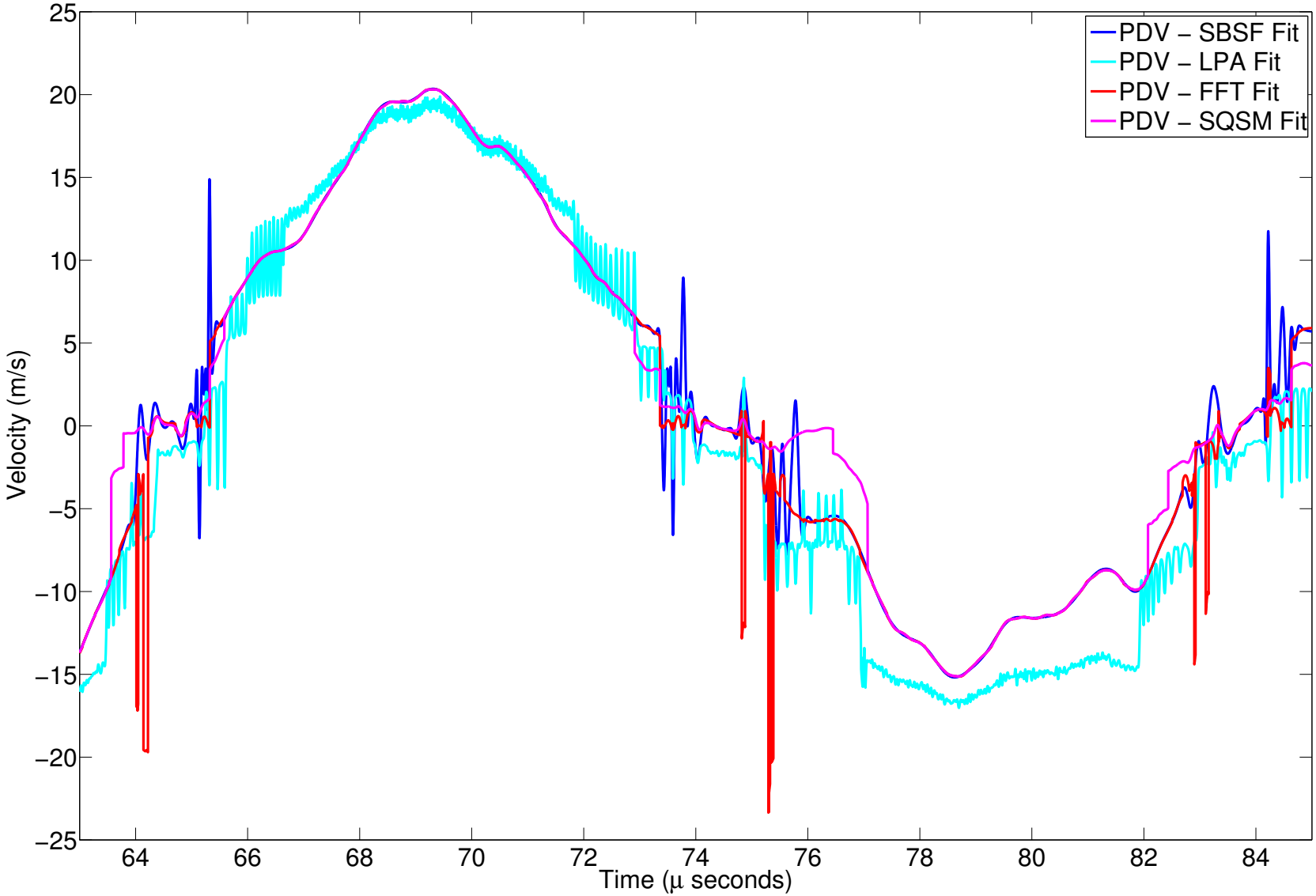
Jump-Off Velocity



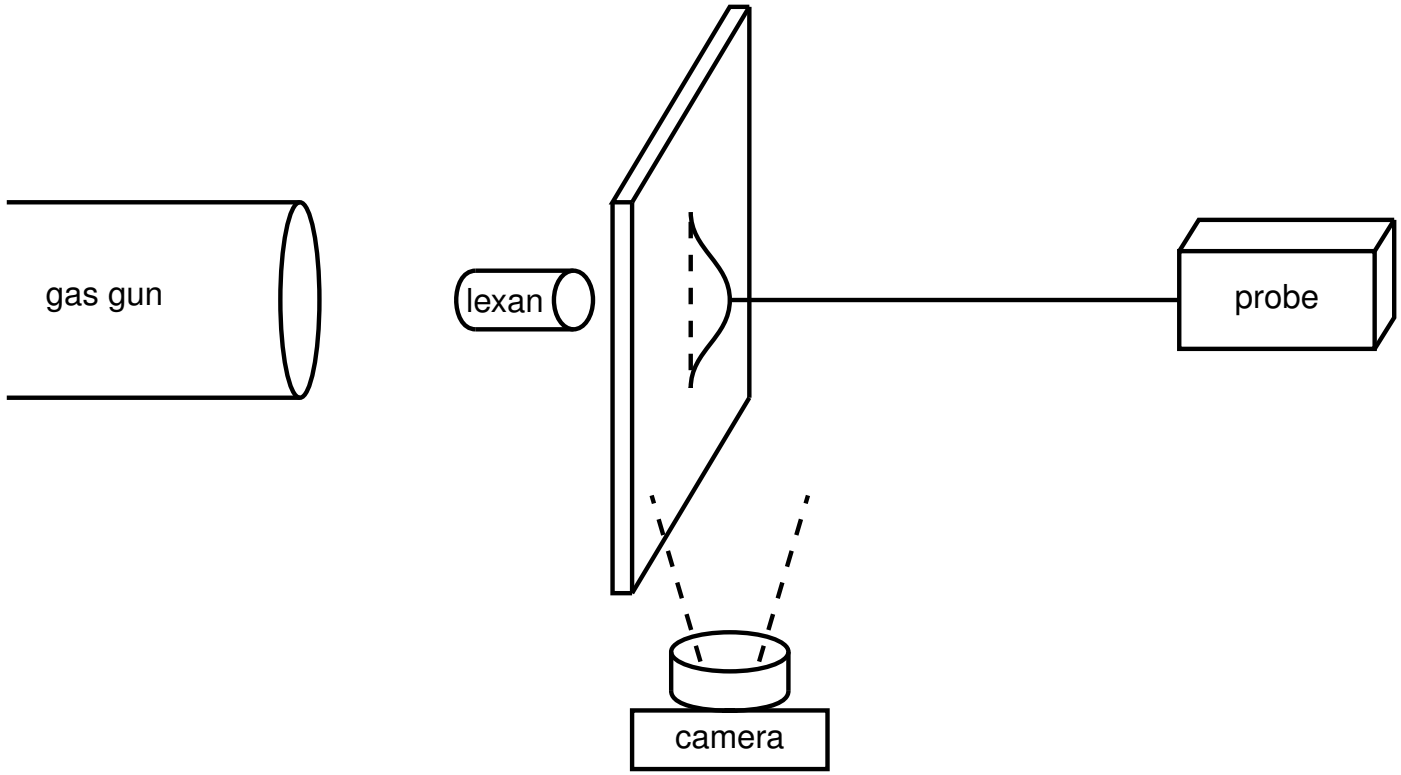
Post Jump-Off Velocity



"Breathing Effect" Velocity



Gas Gun Setup with Video

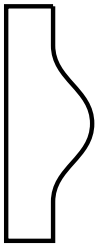


A lexan glass projectile was fired at an A036 steel plate and the surface deformation was studied using PDV and high-speed video.

Estimating Velocity from High-Speed Video

Standard techniques for extracting points of high gradient from the image data were adapted for estimating position and velocity of the leading edge of the surface as a function of time.

Correcting for the Camera Angle

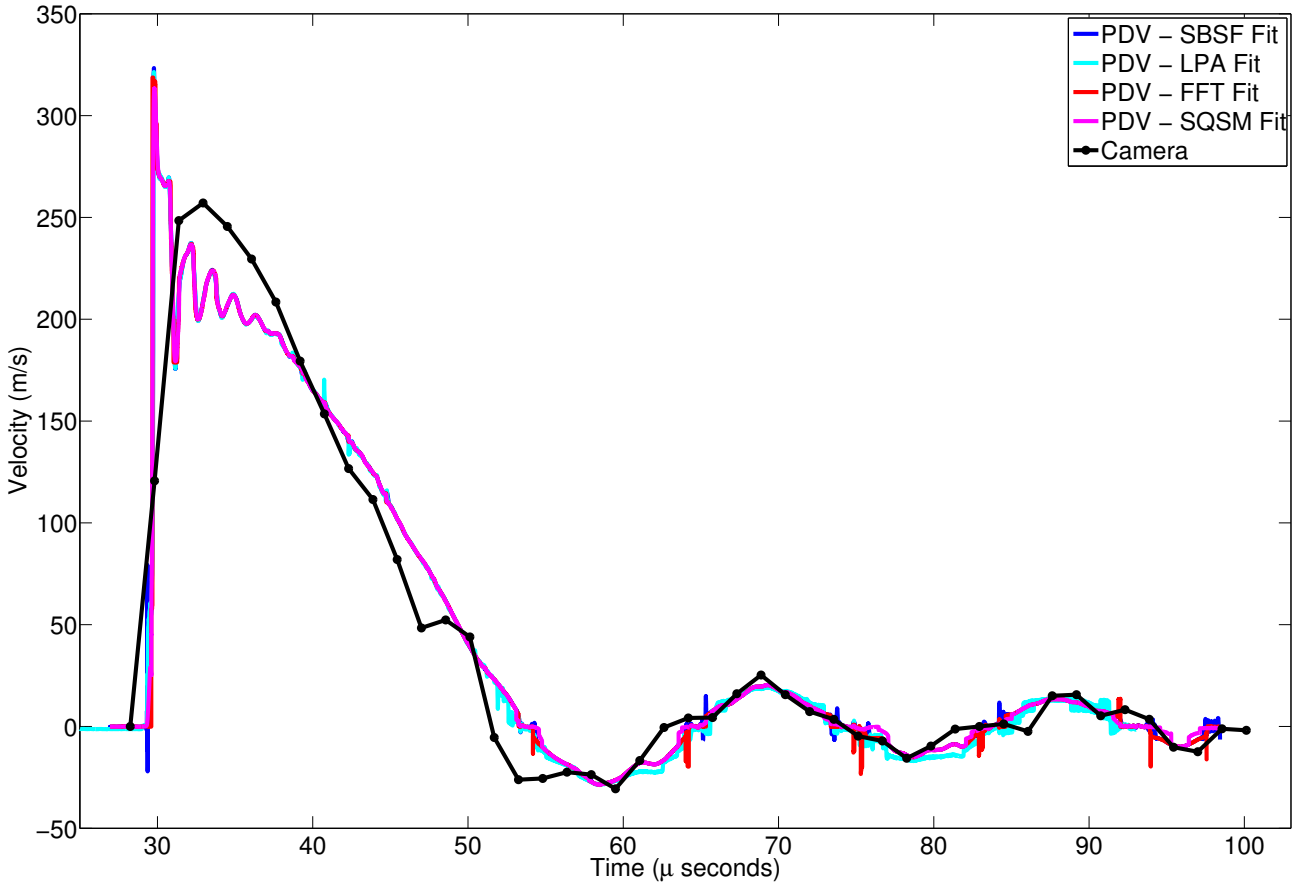


- The camera was slightly offset in the experiment such that its view was not perpendicular to the bulge in the plate.
- The offset results in calculated velocities that are too large.
- The calculated offset angle was 1.0741 degrees.

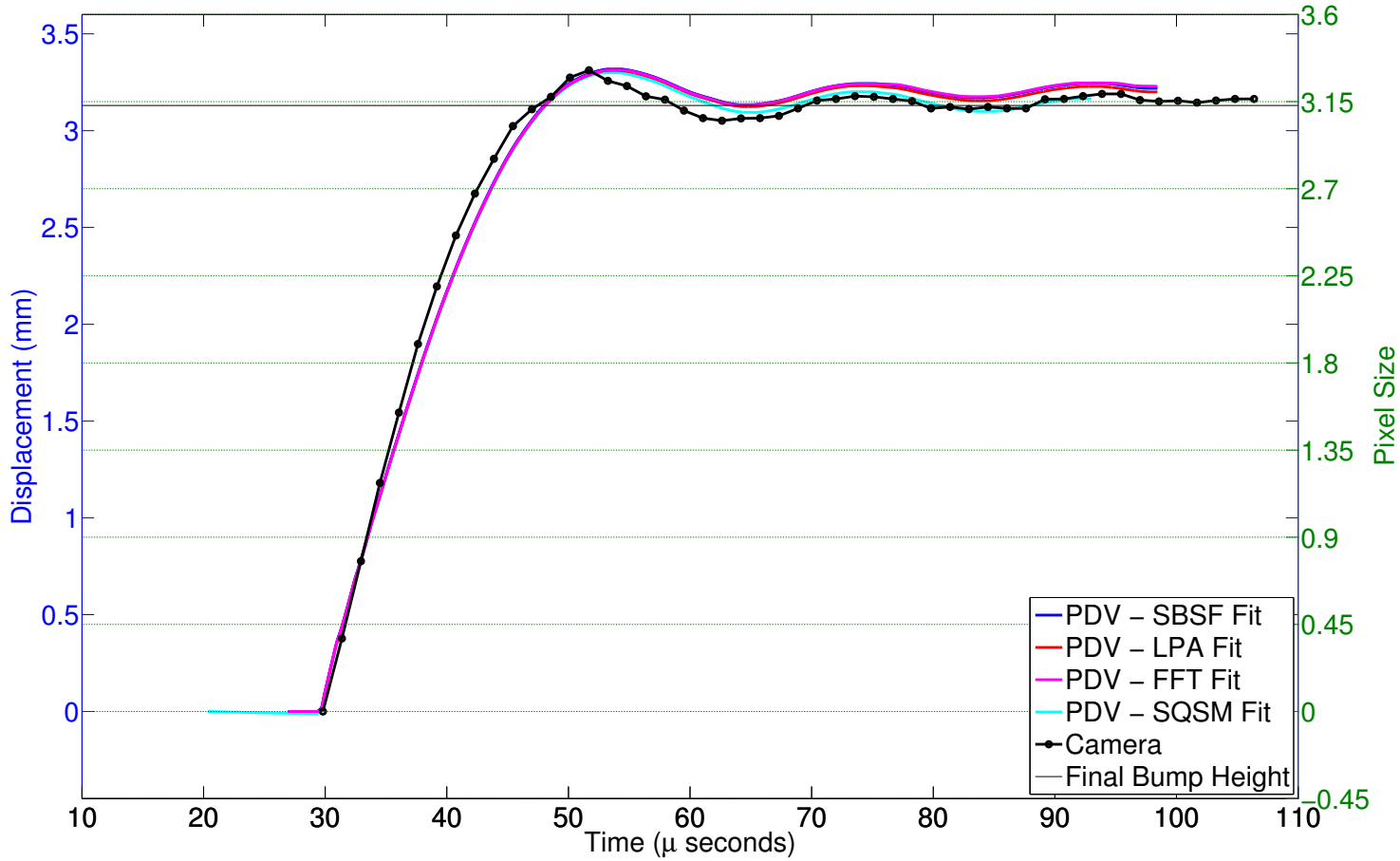
To obtain the corrected velocities, we multiply the computed velocity by the ratio,

$$\text{ratio} = \frac{\text{final bump size (mm)}}{\text{calibrated pixel size (mm/pixel)}} \times \frac{1}{\text{\# video pixels (pixel)}}.$$

Velocity Comparison



- Camera is unable to capture fine-scale feature of impact jump-off
- Relative to camera sampling rate, PDV extraction and camera trace reveal same dynamic features


Displacement (mm)
Pixel Size
Time (μ seconds)
3.5
3
2.5
2
1.5
1
0.5
0
3.6
3.15
2.7
2.25
1.8
1.35
0.9
0.45
0
-0.45
10
20
30
40
50
60
70
80
90
100
110
PDV – SBSF Fit
PDV – LPA Fit
PDV – FFT Fit
PDV – SQSM Fit
Camera
Final Bump Height

Future Work

Continue developing these and other velocity extraction techniques

Conduct further experiments with the gas gun using a hybrid video-framing camera with specs:

- 5 million fps
- 1000x1000 pixels per frame
- 30 μm pixel size